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Completion of One Year Bioventing Test . . .

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5 Jul 94

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DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE
BROOKS AIR FORCE BASE TEXAS

5 Jul 94

MEMORANDUM FOR OO-ALC/EMR
ATTN: Andrew Gemperline

FROM: HQ AFCEE/ERT
8001 Arnold Drive
Brooks AFB TX 78235-5357

SUBJECT: Completion of One Year Bioventing Test, Hill AFB, UT, Sites 204.1, 214.1, 228, and 924.

The Air Force Center for Environmental Excellence (AFCEE) one-year bioventing test and evaluation project at the above sites has been completed. Each site-specific Figure 1 provides general site information and each site-specific Table 1 provides a summary of initial, six-month, and one-year fuel biodegradation rates measured at several monitoring points. Each site-specific Table 2 provides a summary of initial and final soil and soil gas sampling results for total recoverable petroleum hydrocarbons (TRPH) and benzene, toluene, ethylbenzene, and xylenes (BTEX). Based on results from your sites and 109 other sites currently under operation, bioventing is cost-effectively remediating fuel contamination in a reasonable time frame. We recommend its application on your installation using the criteria in the AFCEE Test Plan and Technical Protocol for a Field Treatability Test for Bioventing, May 1992, including Addendum One, February 1994. Given the results from the rigorous testing and evaluation of bioventing at Site 914, AFCEE Bioventing Initiative sites, and base installed bioventing sites, it is obvious that bioventing is a viable remedial alternative that can meet regulatory site closure requirements. AFCEE/ERT recommends that the above sites be slated for final soil sampling in support of site closure.

The objective of the one-year sampling effort was not to collect the large number of samples required for statistical significance. It was conducted to give a qualitative indication of changes in contaminant mass. Soil gas samples are somewhat similar to composite samples in that they are collected over a wider area. Thus, they provide a good indication of changes in soil gas profiles and volatile contaminant mass (see Addendum One to Test Plan and Technical Protocol for a Field Treatability Test for Bioventing - Using Soil Gas Surveys to Determine Bioventing Feasibility and Natural Attenuation Potential, February 1994). Soil samples, on the other hand, are discrete point samples subject to large variabilities over small distances/soil types. Given this variability, coupled with known sampling and analytical variabilities, a large number of samples would have to be collected to conclusively determine "real" changes in soil contamination. Because of the limited number of samples and placement of samples, these results should not be viewed as conclusive indicators of bioventing progress or evidence of the success or failure of this technology. In situ respiration tests are considered to be better indicators of hydrocarbon remediation than limited soil sampling.

 AQ M01-02-0382

Sampling results indicate that a significant reduction in BTEX has taken place in the soils within the estimated treatment radii of the pilot vent wells. Total petroleum hydrocarbons (TRPH or TPH) sampling indicates significant reductions in TRPH levels. However, there are a limited number of examples where one-year sampling results appear higher than initial levels. We know that bioventing does not produce TRPH, and these results are best explained by known variations in subsurface contaminant distribution. All other measurements indicate that fuel biodegradation is progressing at a significant rate. AFCEE recommends that the bioventing pilot systems continue to operate while planning site closure soil sampling. AFCEE/ERT can provide technical coordination, contractual support, and possibly funding for confirmational sampling. Please contact Patrick E. Haas, AFCEE/ERT, DSN 240-4314, commercial 210-536-4314, to discuss technical options for site closure. We plan to conduct statistically significant soil sampling at numerous sites included in the AFCEE Bioventing Initiative. The objective will be to verify the ability of bioventing to achieve desired soil cleanup levels.

Data from your base and many others indicate that BTEX compounds are preferentially biodegraded over TPH. Since BTEX compounds represent the most toxic and mobile fuel constituents, a BTEX standard is a risk-based standard. We strongly encourage its use over an arbitrary TPH standard. Attachment 3 summarizes the BTEX/TPH issue and a report to be sent under separate cover will assist you in negotiating for a BTEX cleanup standard. Our information indicates that Utah currently regulates to TPH and BTEX action levels. "One-year samples" collected in July 1993, and numerous initial samples are well below the individual BTEX action levels (Benzene: 0.2 mg/kg; Toluene: 100 mg/kg; Ethylbenzene: 70 mg/kg; Xylene: 1000 mg/kg). Thus, the toxic and mobile constituents are completely degraded or present in extremely low concentrations. The Utah TPH action level is in most cases lower than the individual BTEX action levels . Given a fresh fuel spill, it would take dramatically higher TPH concentrations to even come close to some of the BTEX action levels. This provides an unfortunate and scientifically conflicting obstacle to ensuring that a risk-based approach is followed. Utah regulations appear to provide for the consideration of site-specific cleanup levels which may allow for a risk-based approach. AFCEE/ERT would appreciate feedback from Hill AFB regarding TPH cleanup levels. We are continuing to research state-specific regulations to identify specific clauses that allow a risk-based approach. In conclusion, a risk-based approach will expedite site closure while reducing overall costs. Please contact Patrick E. Haas for details.

In general, quantitative destruction of BTEX will occur over a 1 to 2 year bioventing period. Soil gas surveys and respiration tests can be used as BTEX destruction indicators. If a non-risk-based/TPH cleanup is chosen, the pilot and full-scale systems should be operated until respiration rates approach background rates. We recommend that confirmatory soil sampling be conducted 4-6 months after background respiration rates are approached. Also, please note that other common in situ technologies like soil vapor extraction follow the same profile of removing BTEX early, TPH late. Since "one-year" sampling was conducted in July 1993, current concentrations of BTEX and TPH are most likely significantly lower.

Because this is a streamlined test and evaluation project, our contract does not provide for additional reports to the base on pilot study results. The interim results report dated Sep 92 contains as-builts and initial data. This letter summarizes all data collected and provides next step recommendations. AFCEE is no longer responsible for the operation, maintenance, or monitoring of the Hill AFB Sites 204.1, 214.1, 228, and 924 bioventing systems. We are initiating a contract to extend monitoring at some sites beyond the initial one-year test. Monitoring will include soil gas and respiration tests to document hydrocarbon degradation. Also, the collection of sufficient final soil samples to statistically demonstrate site cleanup is being contracted at numerous sites. If you are interested, please call us. AFCEE/ERT's and Hill AFB's involvement in the Western Governor's Association Demonstrate On-site Innovative Technologies Initiative should provide a good opportunity to utilize bioventing experiences at Hill AFB to further acceptance and understanding of bioventing principles.

The blower and accessories are now base property and should continue to be used on this or other bioventing sites. Although current equipment is explosion proof, under no circumstances should it be used for soil vapor extraction unless appropriate explosion-proof wiring is provided. If the base does not want to keep the blower or if you have further questions, please contact us at DSN 240-4331 or commercial 210-536-4331. Please notify AFCEE/ERT if inadvertent releases have occurred or further site characterization efforts have detected contamination in areas that were not sampled previously.

On behalf of the AFCEE/ERT staff, I would like to thank you for your support of this bioventing test and evaluation project. The information gained from each site will be invaluable in evaluating this technology and will promote its successful application on other DOD, government, and private sites. I have attached a customer satisfaction survey. Please take a few minutes to fill it out and tell us how we did. We look forward to hearing from you.

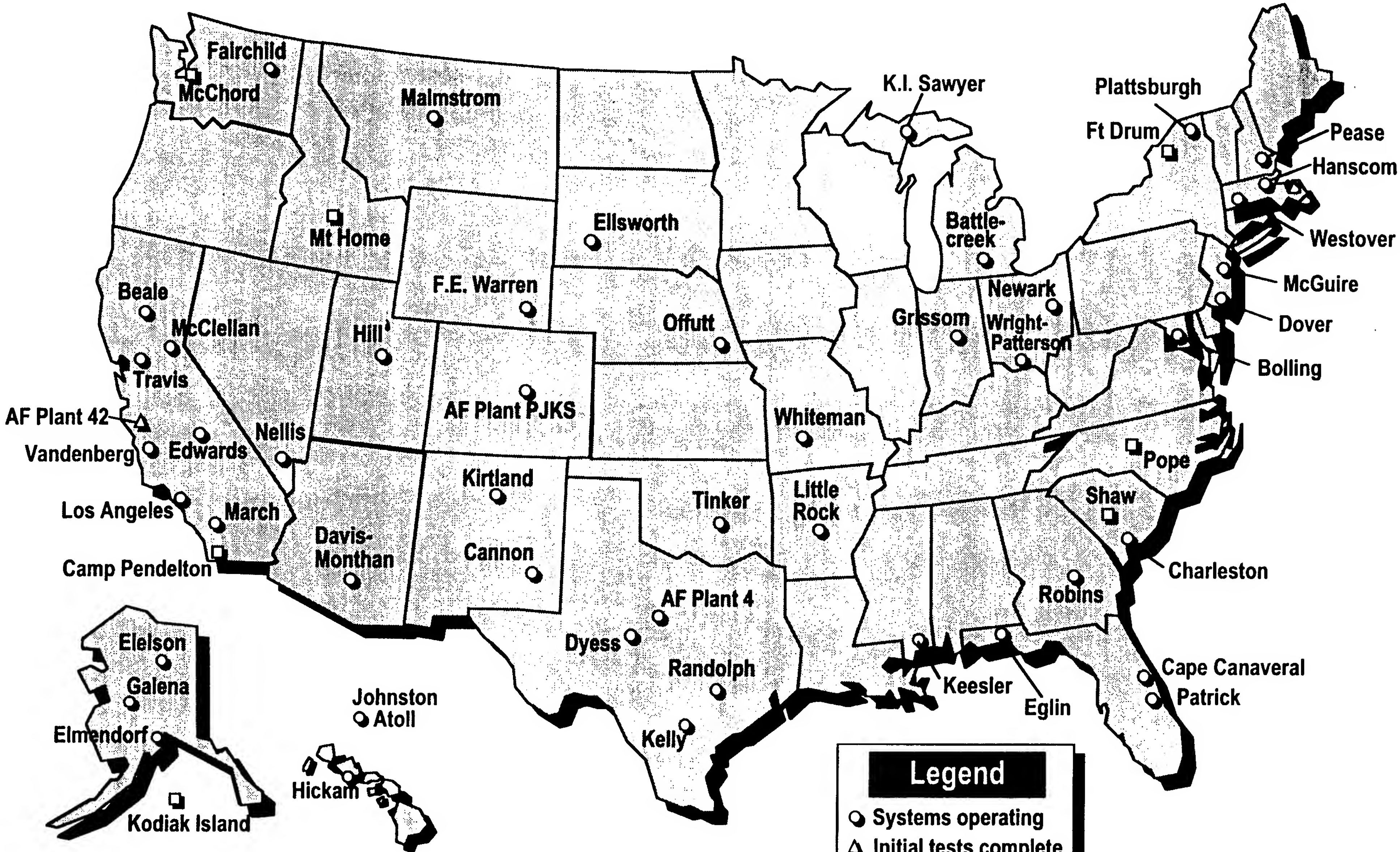
Ross N. Miller

ROSS N. MILLER, Lt Col, USAF, BSC
Chief, Technology Transfer Division

Attachments:
1. AFCEE Bioventing Initiative Site Map
2. Hill AFB Bioventing Data, Tables 1 & 2
3. "Using Risk-based Standards will Shorten Cleanup Time at Petroleum Contaminated Sites"
4. Addendum One to Bioventing Test Plan
5. Survey

cc: HQ AFMC/CEVR
AFCEE/ERD
Western Governor's Association Military Wastes Working Group

AFCEE Bioventing Initiative Sites



Number Bioventing Sites - 130

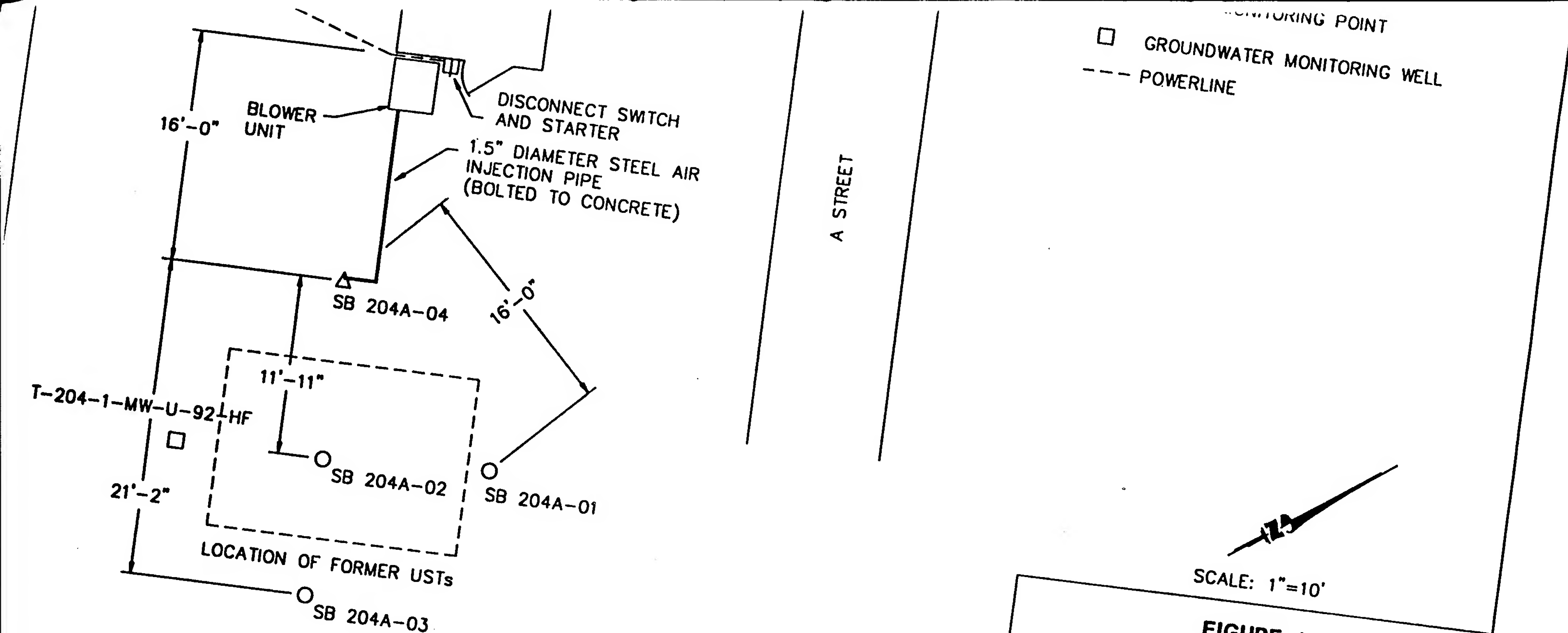


FIGURE 1

BLOWER LOCATION AS-BUILT
SITE 204.1

HILL AFB, UTAH

ENGINEERING-SCIENCE, INC.
Denver, Colorado

)-01, 06/30/93 at 14:39

Location (Depth, feet bgs)	Initial (July 1992)			6-Month (Feb.-Mar. 1993)			1-Year (July 1993)		
	K_o (% O_2/min)	Degradation Rate (mg/kg/year)[a/] [b/]	Soil Temperature (°C)	K_o (% O_2/min)	Degradation Rate (mg/kg/year)[b/]	Soil Temperature (°C)	K_o (% O_2/min)	Degradation Rate (mg/kg/year)	Soil Temperature (°C)
SB204A-04 (10-50)[c/]	.026	9800	NS[d/]	.0021	790	NS	.0017	640	NS
SB204A-01 (27-28)	NS	NS	NS	0.00049	160[e/]	NS	NS	NS	NS
SB204A-01 (34-35)	.0062	2700	NS	.0008	350	NS	.0005	220	NS
SB204A-02 (11-12)	.017	3000	NS	NS	NS	NS	.0026	470	NS
SB204A-03 (12-13)	NS	NS	NS	.0004	130[e/]	NS	NS	NS	NS

[a/] Milligrams of hydrocarbons per kilogram of soil per year.
[b/] Calculated using moisture content of soil sample collected from the location in July 1993.
[c/] Vent well.
[d/] Well installation was performed by another contractor, no thermocouples were installed. NS=Not Sampled.
[e/] Assumes average moisture content of the soil samples collected in July 1993.

SITE 204.1
INITIAL AND 1–YEAR SOIL AND SOIL GAS ANALYTICAL RESULTS
HILL AFB, UTAH

Analyte (Units)[a/]	Sample Location (Depth, feet below ground surface)					
	SB204A–04 (10–50)[b/]		SB204A–01 (34–35)		SB204A–02 (11–12)	
Soil Gas Hydrocarbons	Initial[c/]	1–Year[d/]	Initial	1–Year	Initial	1–Year
TVH (ppmv)	490	7.6	7.5	0.27	160	1.7
Benzene (ppmv)	.016	.005	.010	<.002	.053	<.003
Toluene (ppmv)	.25	.009	.006	<.002	.060	.004
Ethylbenzene (ppmv)	.17	<.002	<.002	<.002	.085	<.003
Xylenes (ppmv)	.85	.003	<.002	<.002	.31	.003

	SB204A–04 (12.5–13)		SB204A–01 (9–9.5)		SB204A–02 (11–12)	
Soil Hydrocarbons	Initial[e/]	1–Year[f/]	Initial	1–Year	Initial	1–Year
TRPH (mg/kg)	1500	660	370	1750	1000	11200
Benzene (mg/kg)	.023	<.03	.009	<.0003	.031	<.03
Toluene (mg/kg)	.26	<.03	<.005	.0004	.22	<.03
Ethylbenzene (mg/kg)	.78	<.03	.047	<.0003	.8	<.03
Xylenes (mg/kg)	7.4	<.03	.19	<.0007	7.7	.25
Moisture (%)	NS[g/]	5.0	4.8[h/]	3.0	NS	15.0

[a/] TVH= total volatile hydrocarbons; ppmv=parts per million, volume per volume;
TRPH=total recoverable petroleum hydrocarbons; mg/kg=milligrams per kilogram.

[b/] Vent well.

[c/] Initial soil gas samples collected on 7/7/92.

[d/] 1–Year soil gas samples collected on 7/19/93.

[e/] Initial soil samples collected by Montgomery–Watson, Inc. from 5/4/92 to 5/7/92.

[f/] 1–Year soil samples collected on 8/10/93.

[g/] NS=Not Sampled.

[h/] Average soil moisture content of analytical samples collected from borehole SB204A–01.

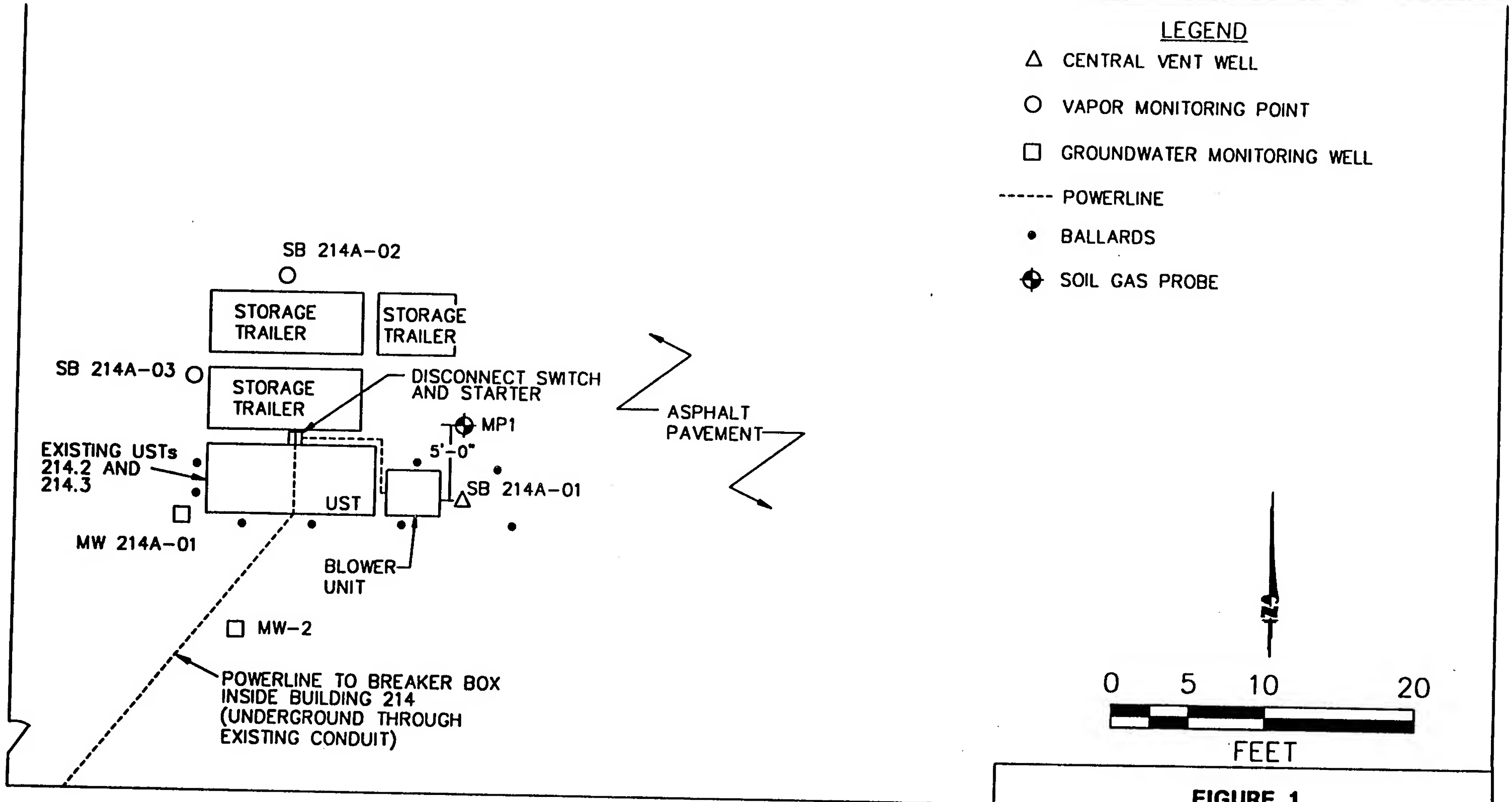


FIGURE 1

BLOWER LOCATION AS-BUILT
SITE 214.1

HILL AFB, UTAH

ENGINEERING-SCIENCE, INC.
Denver, Colorado

26809-02, 06/30/93 at 13:34

TABLE 1
SITE 214.1
RESPIRATION AND DEGRADATION RATES
HILL AFB, UTAH

Location (Depth, feet bgs)	Initial (July 1992)			6-Month (Feb.-Mar. 1993)			1-Year (July 1993)		
	K_o (% O_2/min)	Degradation Rate (mg/kg/year)[a/]	Soil Temperature (°C)	K_o (% O_2/min)	Degradation Rate (mg/kg/year)[b/]	Soil Temperature (°C)	K_o (% O_2/min)	Degradation Rate (mg/kg/year)[b/]	Soil Temperature (°C)
SB214A-01 (5-60)[c/]	0.0051[d/]	540	NS[e/]	.00025	27	NS	.00025	27	NS

[a/] Milligrams of hydrocarbons per kilogram of soil per year.
[b/] Assumes moisture content of the soil is the same as the initial level at SB214A-01.
[c/] Vent well.
[d/] Temporary vapor probe MP-1 was installed at 12 feet below grade 5 feet north of SB214A-01 for initial testing.
[e/] Well installation was performed by another contractor, no thermocouples were installed. NS=Not Sampled.

TABLE 2
SITE 214.1
INITIAL AND 1-YEAR SOIL AND SOIL GAS ANALYTICAL RESULTS
HILL AFB, UTAH

Analyte (Units)[a]	Sample Location (Depth, feet below ground surface)	
	SB214A-01 (5-60)	
Soil Gas Hydrocarbons	Initial[b]	1-Year[c]
TVH (ppmv)	960	620
Benzene (ppmv)	.019	<.029
Toluene (ppmv)	.076	<.029
Ethylbenzene (ppmv)	.52	.036
Xylenes (ppmv)	.51	.18
	SB214A-01 (11-12)	
Soil Hydrocarbons	Initial[d]	1-Year[e]
TRPH (mg/kg)	36200	550
Benzene (mg/kg)	<.05	<.0002
Toluene (mg/kg)	1.15	<.0002
Ethylbenzene (mg/kg)	5.84	<.0002
Xylenes (mg/kg)	65.8	<.0002
Moisture (%)	19.0	NS[f]

a/ TVH= total volatile hydrocarbons; ppmv=parts per million, volume per volume;
TRPH=total recoverable petroleum hydrocarbons; mg/kg=milligrams per kilogram.
b/ Initial soil gas sample collected on 7/7/92.
c/ 1-Year soil gas sample collected on 7/19/93.
d/ Initial soil samples collected by Montgomery-Watson, Inc. on 11/1/91.
e/ 1-Year soil sample collected on 8/3/93.
f/ NS=Not Sampled.

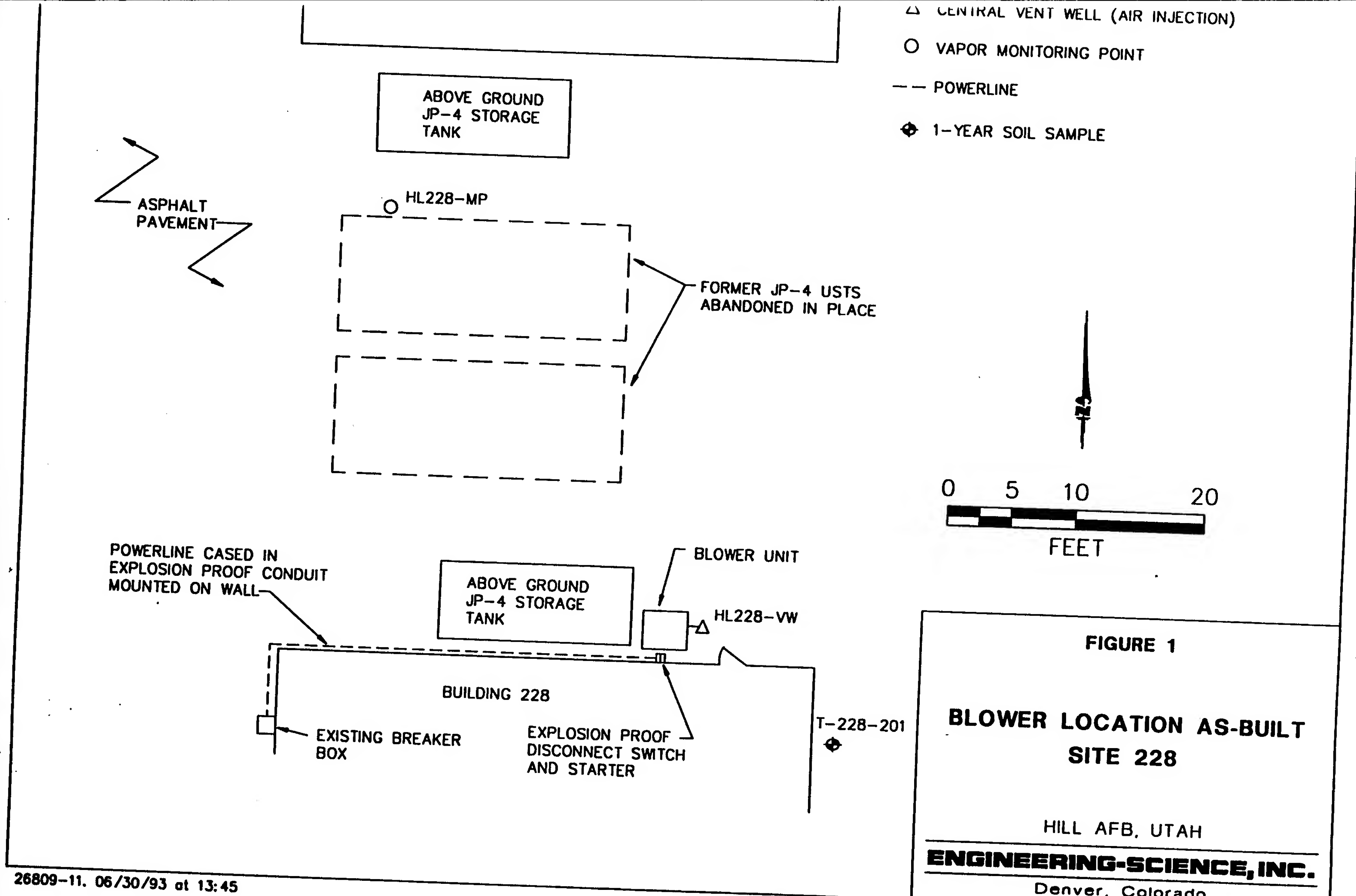


FIGURE 1

BLOWER LOCATION AS-BUILT
SITE 228

HILL AFB, UTAH

ENGINEERING-SCIENCE, INC.
Denver, Colorado

26809-11, 06/30/93 at 13:45

TABLE 1
SITE 228
RESPIRATION AND DEGRADATION RATES
HILL AFB, UTAH

Location (Depth, feet bgs)	Initial (July 1992)			6-Month (Feb.-Mar. 1993)			1-Year (July 1993)		
	K_o (% O_2/min)	Degradation Rate (mg/kg/year)[a/]	Soil Temperature (°C)	K_o (% O_2/min)	Degradation Rate (mg/kg/year)[b/]	Soil Temperature (°C)	K_o (% O_2/min)	Degradation Rate (mg/kg/year)[b/]	Soil Temperature (°C)
HL228-VW (10-40)	NS[c/]	NS	NS[d/]	.00004	10	NS	.00007	17	NS
HL228-MP (28-29)	.009	2200	NS	.001	250	NS	.0019	470	NS

[a/] Milligrams of hydrocarbons per kilogram of soil per year.
[b/] Assumes moisture content of the soil is the same as the initial level at HL228-VW.
[c/] NS=Not Sampled.
[d/] Well installation was performed by another contractor, no thermocouples were installed.

TABLE 2
SITE 228
INITIAL AND 1–YEAR SOIL AND SOIL GAS ANALYTICAL RESULTS
HILL AFB, UTAH

Analyte (Units)[a/]	Sample Location (Depth, feet below ground surface)			
	HL228–VW (10–40)		HL228–MP (28–29)	
Soil Gas Hydrocarbons	Initial[b/]	1–Year[c/ d/]	Initial[d/]	1–Year[d/]
TVH (ppmv)	42	27	2700	12
Benzene (ppmv)	.06	.03	1.55	.012
Toluene (ppmv)	.009	.0135	4.4	.044
Ethylbenzene (ppmv)	.002	.019	1.7	.013
Xylenes (ppmv)	.018	.205	9.45	.051
	HL228–VW (27.5–28)		HL228–MP (28–28.5)	
Soil Hydrocarbons	Initial[e/]	1–Year[f/]	Initial	1–Year[g/]
TRPH (mg/kg)	5000	<5.4	6,500	NS[h/]
Benzene (mg/kg)	1.2	<.0006	0.08	NS
Toluene (mg/kg)	12	<.0006	6.3	NS
Ethylbenzene (mg/kg)	6.1	<.0006	8.1	NS
Xylenes (mg/kg)	220	<.0008	260	NS
Moisture (%)	11.7[i/]	8.0	NS	NS

a/ TVH= total volatile hydrocarbons; ppmv=parts per million, volume per volume;
TRPH=total recoverable petroleum hydrocarbons; mg/kg=milligrams per kilogram.
b/ Initial soil gas samples collected on 7/6/92 and 7/7/92.
c/ 1–Year soil gas samples collected on 7/19/93.
d/ Average of two duplicate samples.
e/ Initial soil samples collected by Montgomery–Watson, Inc. on 5/18/92.
f/ 1–Year soil samples collected at location T–228–201 (28.5–29) on 9/11/93.
g/ Sample could not be collected due to presence of underground utilities.
h/ NS=Not Sampled.
i/ Average soil moisture content from samples collected at HL228–VW.

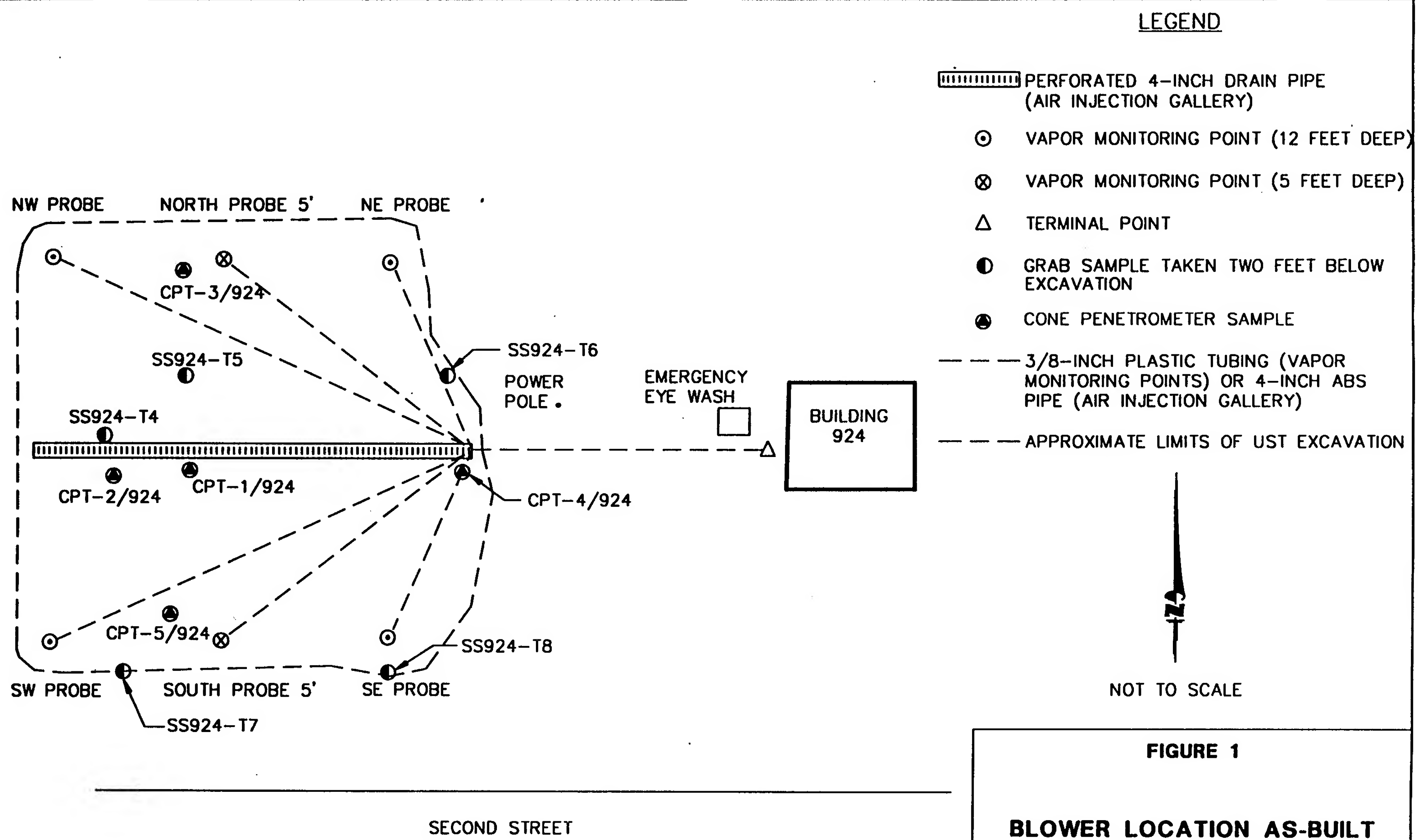


FIGURE 1

BLOWER LOCATION AS-BUILT
SITE 924

HILL AFB, UTAH

ENGINEERING-SCIENCE, INC.
Denver, Colorado

26809-04, 06/24/92 at 15:30

TABLE 1
SITE 924
RESPIRATION AND DEGRADATION RATES
HILL AFB, UTAH

	Initial (July 1992)			6-Month (March 1993)			1-Year (July 1993)		
Location (Depth, feet bgs)	K_o (% O_2/min)	Degradation Rate (mg/kg/year)[a/ b/]	Soil Temperature (°C)	K_o (% O_2/min)	Degradation Rate (mg/kg/year)[b/]	Soil Temperature (°C)	K_o (% O_2/min)	Degradation Rate (mg/kg/year)[b/]	Soil Temperature (°C)
HL924-VW (12)	.014	5000	NS[c/]	NS	NS	NS	.00008	28	NS
HL924-SE (12)	.013	4600	NS	.0012	430	NS	.00018	64	NS
HL924-S (5)	.009	3200	NS	NS[d/]	NS	NS	NS	NS	NS
HL924-SW (12)	.0011	390	NS	.00024	85	NS	.00009	32	NS

a/ Milligrams of hydrocarbons per kilogram of soil per year.
b/ Calculated using average moisture content of soil samples collected from Site 924.5, north of Bldg 924.
c/ Well installation was completed by another contractor, no thermocouples were installed. NS=Not Sampled.
d/ Monitoring point HL924-S was destroyed during site construction activity in Fall 1992.

TABLE 2
SITE 924
INITIAL AND 1-YEAR SOIL AND SOIL GAS ANALYTICAL RESULTS
HILL AFB, UTAH

Analyte (Units)[a]	Sample Location (Depth, feet below ground surface)					
	HL-924-VW (12)		HL-924-SE (12)		HL-924-S (5)	
Soil Gas Hydrocarbons	Initial[b]	1-Year[c]	Initial[d]	1-Year[d]	Initial	1-Year[e]
TVH (ppmv)	13	.27	4800	2.75	1800	NS
Benzene (ppmv)	.016	<.002	61	.004	15	NS
Toluene (ppmv)	.12	.006	145	.003	30	NS
Ethylbenzene (ppmv)	.013	<.002	6.7	<.003	1	NS
Xylenes (ppmv)	.16	<.002	63.5	<.003	8.6	NS

	SS924-T4 (14)	SS924-T5 (14)	SS924-T6 (14)	SS924-T7 (14)	SS924-T8 (14)	CPT-1/924 (30-30.5)	CPT-2/924 (30-30.5)	CPT-3/924 (25-25.5)	CPT-4/924 (20-20.5)	CPT-5/924 (10-10.5)
Soil Hydrocarbons	Initial[f]					1-Year[g]				
TRPH (mg/kg)	<1.0	<1.0	<1.0	<1.0	14.7	<10.0	<10.0	<10.0	<10.0	<10.0
Benzene (mg/kg)	<0.2	<0.2	<0.2	<0.2	<0.2	<.01	<.01	<.01	<.01	<.01
Toluene (mg/kg)	<0.2	<0.2	<0.2	<0.2	<0.2	.033	<.01	.016	.029	.024
Ethylbenzene (mg/kg)	<0.2	<0.2	<0.2	<0.2	.24	.014	<.01	<.01	<.01	<.01
Xylenes (mg/kg)	<0.2	<0.2	<0.2	<0.2	1.01	.105	<.02	<.02	<.02	<.02
Moisture (%)	NS	NS	NS	NS	NS	17.8	8.1	19.6	20.8	17.1

[a] TVH = total volatile hydrocarbons; ppmv=parts per million, volume per volume;
TRPH=total recoverable petroleum hydrocarbons; mg/kg=milligrams per kilogram.
[b] Initial soil gas samples collected on 7/7/92.
[c] 1-Year soil gas samples collected on 7/19/93.
[d] Average of two duplicate samples.
[e] No sample could be collected due to subsurface obstruction; NS=Not Sampled.
[f] Initial soil samples collected by D+W Construction on 5/19/92.
[g] 1-Year soil samples collected by Montgomery-Watson, Inc. on 11/19/92.

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